Promising Practices for The Expansion and Sustainability of Summer Bridge Programs for Underrepresented Engineering Students at The Pennsylvania State University

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Abstract

There are well-documented calls for increasing the numbers of students who graduate with a baccalaureate STEM degree, especially racially underrepresented students. The Center for Engineering Outreach and Inclusion at Penn State is comprised of five units focused on increasing the likelihood of graduating with a baccalaureate degree in Engineering among racially underrepresented students, women, and first-generation college students across all 19 Penn State campuses. This paper highlights one of the units. The Sustainable Bridges from Campus to Campus project is a NSF-sponsored IUSE study focused on retaining racially underrepresented students in Engineering, especially those who start at a regional campus. Penn State is comprised of the flagship University Park campus and 18 regional undergraduate campuses. About 60% of Penn State students opt for the “2+2 plan” by completing the first two years of their education at a regional campus and then transition to the University Park campus for the last two years. One reason to focus on regional campus students is because half of the racially underrepresented students in Engineering begin their Penn State career at a regional campus. This paper focuses on promising practices to expand and sustain summer bridge academic enhancement programs beyond the traditional model of a residential program at a Research I university. This presentation will discuss (a) different models for summer bridge programs, (b) strategies for sustaining summer bridge programs, (c) the Center for Engineering Outreach and Inclusion at Penn State, and (d) lessons learned regarding the implementation of summer bridge programs for STEM students.
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Different Models for Summer Bridge Programs

Summer bridge programs are widely used at universities to assist undergraduate students make the transition to college, be successful academically, and be retained through graduation. These programs are typically for students who need additional support (e.g., first-generation, low-income, underrepresented, academically underprepared students; e.g., Sablan, 2014; St. John, Masse, Fisher, Moronski-Chapman & Lee, 2014). Implementation of summer bridge programs varies (Sablan, 2014). They are often 4- to 6-week residential programs for incoming first-year students at a large university and focus on college readiness including content knowledge (e.g., math, English), cognitive strategies (e.g., problem solving, critical analysis), academic behaviors (e.g., study skills, time management), and “college knowledge” (e.g., how to access and utilize services and offices on campus). Sablan (2014) reviewed the published reports of 11 summer bridge programs. The outcome measures were typically grade point average (GPA), retention, grades in a specific course, or academic self-efficacy. Sample sizes varied from 28 to 2200 students. Ten of the studies had correlational or quasi-experimental designs, and one had an experimental design with random assignment to a bridge program or a control group. Seven of the studies showed positive results for students who participated in a bridge program, two showed mixed results, one showed negative results, and one showed no effect.

A subset of summer bridge programs focus on underrepresented students intending to major in science, technology, engineering, or math (STEM). The impetus for those bridge programs is to address the problem of low numbers of racially underrepresented individuals in STEM fields. The problem was described as “urgent” by the Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline (2011). Racially underrepresented students enter STEM majors in college at similar rates as white and Asian American students, but have much higher rates of attrition (American Council on Education, 2005). Racially underrepresented students earn approximately 12% of the baccalaureate degrees in Engineering, less than half of their representation in the population (28%; National Science Foundation, 2013).

Two long-standing bridge programs in the College of Engineering at Penn State. The Center for Engineering Outreach and Inclusion at Penn State (formerly the Office of Engineering Diversity) has conducted summer bridge programs for incoming underrepresented Engineering students for over 20 years at the flagship University Park campus. The overarching goal is to increase graduation rates in a STEM major, particularly Engineering, among incoming underrepresented students. Consistent with the Meyerhoff Scholars Program, this goal can be achieved through academic and social integration, skill development, support, and monitoring and advising (e.g., Maton & Hrabowski, 2004). Both Penn State University Park bridge programs are residential and math-intensive on the campus of a large Research 1 university. The daily bridge
schedule is full. Academic instruction and support are scheduled for most of the day (9am to 5pm) followed by evening study sessions (7-9pm). During the day there are also activities to acclimate students to college life and the campus, foster peer relationships, and provide professional development. Social activities and study sessions are scheduled for the weekends.

The two bridge programs on the Penn State University Park campus differ in several ways including the math content and campus assignment in the fall. The PreFirst Year in Engineering and Science Scholars (PreF) program focuses on incoming underrepresented STEM students assigned to the University Park campus who are calculus ready. The goal is to increase their likelihood of graduation with a baccalaureate STEM degree. Among the African American, Hispanic American, and Native American students who start at the University Park campus, a high proportion are first-generation college students and enter college with less math preparation. The PreF program is a 6-week residential bridge program and reviews calculus and chemistry for approximately 30 incoming first-year STEM majors, most of whom are Engineering majors. During the academic year, there is ongoing support for the bridge students. They live together in a STEM residence hall and work with mentors, are enrolled together in a first-year seminar in the fall, and are invited to participate in the bi-weekly activities sponsored by the Multicultural Engineering Program (MEP).

The Academic Summer Enhancement (ASE) Program is a math-intensive, residential, 6-week orientation located at the Penn State University Park campus for 20 incoming underrepresented STEM students assigned to one of the regional campuses in the fall semester and who placed into pre-calculus. ASE participants review pre-calculus and entry-level chemistry to promote success in the first-year courses they will take in the fall. Students also receive professional development training, several university technical tours, and a field trip to a corporate location. An important difference between the ASE and the PreF programs is that ASE students attend a bridge program at a different campus than the one they will attend in the fall. Typically, there is one or two students in the program from each regional campus in the ASE program. When the bridge program ends, the bridge students disperse to attend different regional campuses for the fall semester. A second important difference between the two bridge programs is that there is no ongoing academic-year support for the ASE students.

The Toys’n MORE project. Two NSF-funded projects have allowed us to explore other variations of summer bridge programs for Penn State STEM students. The goal of the Toys’n MORE project (NSF STEP #0756992, 2008 to 2014) was to increase retention by 10% at graduation among students pursuing baccalaureate STEM degrees, particularly Engineering, who started their Penn State education at a regional campus. The innovation of the Campus College Connection intervention, as part of the Toys’n MORE project, was that academic and professional enrichment bridge programs were available for the first time at three regional campuses for students who started their Penn State education at those regional campuses. The following types of students who intended to be STEM majors were encouraged to enroll in the new regional bridge programs: women, first-generation college students, African-American students, and
Hispanic-American students. The traditional bridge model, residential summer instruction at the main University Park campus, was modified to fit the needs of the regional campuses. The three bridge programs varied in size (10 to 30 students), length (2, 4, or 8 weeks), and residential status. In addition to academic preparation, a goal of the regional bridge programs was to have the students form learning communities to provide academic support and personal encouragement during the first year, build relationships with faculty and staff, and acclimate to their college campus before the start of the fall semester. Math-intensive summer bridge programs sponsored by the Toys’n MORE project were offered four times at three regional campuses (2010-2013). The participants were 73% male and 64% white.

We demonstrated that offering the Campus College Connection math-intensive summer bridge programs for underserved STEM students at three regional campuses resulted in increases in retention that exceeded the 10% target (Cohan et al., 2014). We aggregated the data for the three bridge programs and examined the efficacy of the new regional summer bridge programs for STEM students in three ways and found evidence for higher retention in Engineering for incoming underserved Engineering students. First, we examined junior-year retention (post Entrance to Major) for the first three cohorts (2010, 2011, 2012). Retention in Engineering was 57%, retention in STEM was 72%, and retention at the University was 77%. The 57% junior-year retention in Engineering exceeded the 42% average junior-year retention in Engineering across all of the regional campuses by 15 percentage points. A chi-squared analysis confirmed that that difference was statistically significant by comparing junior-year Engineering retention among the Campus College Connection students versus all regional campus Engineering students (FA2004-SP2010), $\chi^2 = 7.1$, $p < .01$; Odds Ratio = 1.8. **Campus College Connection bridge students were 1.8 times (or nearly 2 times) more likely to be retained in Engineering in the junior year compared to regional campus Engineering students who did not enroll in a summer bridge program.**

Second, we examined the projected 6-year graduation rates in Engineering for the 2010, 2011, and 2012 Campus College Connection cohorts using institutional data on retention in Engineering after the junior year and the Campus College Connection Engineering students’ junior major status. The institutional data for the most recent years for which 6-year graduation data are available in the College of Engineering (2002-2007) indicated that 84% of students who were junior-year Engineering majors graduated in Engineering within 6 years. Based on that rate of 84% retention following Entrance to Major, we would expect that 40 out of the 48 Campus College Connection students who were junior Engineering majors ($48 \times .84$) would graduate in Engineering in 6 years. If we project that 40 students will graduate in Engineering out of an original total of 85 incoming Engineering majors for the first three cohorts, then the projected 6-year graduation rate in Engineering for those students is 47% (40/85). In comparison, using institutional data for 2004 to 2006 prior to Toys’n MORE, the 6-year graduation rate in Engineering for all of the regional campuses was 30%. Therefore, we would expect a 17 percentage point difference in retention for the first three Campus College Connection cohorts over Engineering students at those three
campuses prior to the intervention (47% - 30%). The difference of 17 percentage points translates into a net gain of 14 underserved students who are projected to graduate in Engineering from the regional summer bridge cohorts (85 x .17).

Third, to further enhance our understanding of how successful the Toys’n MORE bridge programs were at retention, we used another benchmark--comparison against a matched comparison sample for the 2010 and 2011 cohorts. We built a matched sample of nonparticipants to compare to the 2010 and 2011 Toys’n MORE bridge participants. To increase the likelihood that the 2010 and 2011 Toys’n MORE bridge program participants were similar to the incoming students who did not participate in the Toys’n MORE bridges, they were matched on five demographic and academic variables including gender, race/ethnicity, specific regional campus, intended STEM major (either Science, Technology, Engineering, or Math), and SAT math score within one standard deviation for the sample. In order to retain them, eight participants were matched to nonparticipants at a different campus because a match could not be identified at their campus. Twelve participants were dropped from the matched comparison analysis because they were undeclared as freshmen (i.e., their intended major was unknown) or could not be matched to a nonparticipant at their campus or another campus. Thus the matched comparison analysis for the 2010 and 2011 Campus College Connection cohorts examined a reduced sample of 70 out of 82 STEM students (85%) and 70 nonparticipants from the 2010 and 2011 incoming students. As intended, SAT Math scores did not differ statistically between the participants (M = 531, SD = 79) and the matched comparison students (M = 536, SD = 86), suggesting that math aptitude was similar between the two groups, t(137) < 1, ns. Retention in Engineering, STEM, and at Penn State was greater among the Toys’n MORE bridge students by 4, 12, and 9 percentage points, respectively, compared to the matched comparisons. The results were encouraging and suggested that the Toys’n MORE bridge programs at three regional campuses were successful in retaining underserved STEM students. Because of relatively small samples sizes for each regional campus bridge program, analyses to compare them against each other were not conducted.

The Toys’n MORE project focused on implementation and did not include ongoing planning for long-term sustainability during the course of the project. Consequently, the 3 regional campus bridge programs were not sustained beyond the NSF funding. The need to start planning early for long-term sustainability was one of the lessons learned from the Toys’n MORE project and informed a subsequent related project, the Engineering Ahead project.

The Sustainable Bridges from Campus to Campus project (aka Engineering Ahead). The NSF STEP Toys’n MORE project allowed us to show that in the Penn State system STEM summer bridge programs could be conducted successfully at small regional two-year campuses that did not have a tradition of summer bridge programs. We realized there was more work to be done and sought to build on that success in three ways with the Sustainable Bridges from Campus to Campus project (publicly known as Engineering Ahead; NSF IUSE #1525367, 2016 to 2020). As of December 2017, we completed the second year of this 5-year project that focuses on (a) retention
of racially underrepresented students in Engineering, (b) comprehensive bridging across three transitions (incoming first-year students, rising sophomores, juniors transferring from a regional campus to the flagship campus), and (c) long-term sustainability. This project includes three summer bridges at regional campuses for incoming first-year Engineering students and one summer bridge for rising sophomores. Data evaluating the efficacy of these bridge programs are not yet available.

**Different summer bridge models through the Penn State College of Engineering.** All of the math-intensive bridge programs through the College of Engineering at Penn State seek to increase graduation rates in STEM, particularly Engineering, among underrepresented students. Each bridge program includes a minimum of 30 hours of math instruction. Considering the two long-standing Penn State bridge programs along with the seven summer bridges supported by two NSF-funded projects, bridge programs have been administered in a variety of ways according to local needs and context. Penn State Engineering bridge programs vary by location, residential status, structure, length (# of weeks), hours of engagement with math, degree of ongoing support, number of students in the program, and the student’s year in college. One of the 4-week residential bridge programs is for rising sophomores in Engineering. All other bridge programs are for incoming first-year Engineering (STEM) students.

- **Location of summer bridge program and campus assignment**
  - Location of bridge program is the *same* as the campus assigned to for the fall semester (either flagship or regional campus)
  - Location of bridge program is *different* from the campus assigned to for the fall semester (attend summer bridge at flagship campus, attend fall semester at regional campus)

- **Residential status and length of program**
  - Residential program
    - 4-week program (incoming first-year students, rising sophomores)
    - 6-week program (incoming first-year students)
  - Non-residential bridge program for incoming first-year students
    - 2-week program that compressed 30 hours of math instruction into 2 weeks plus an overview of chemistry, physics, and English.
    - 4-week program focused on pre-calculus in the morning and hands-on engineering design in the afternoon
    - 6-week program focused on pre-calculus and calculus, chemistry, and physics
    - 8-week program with four components (for 2 weeks students are in structured programming in Engineering and campus introduction, for 6 weeks students participate in a 30-hour individualized, self-paced academic preparation in math and English on a drop-in basis)
• Structure
  o Structured program—All but one of the bridge programs have been structured with students attending for most of the day and participation in formal academic instruction and activities to build a learning community as a group.
  o Semi-structured program—For the 8-week non-residential program, students participated in structured programming as a group for the first and last weeks. For the middle 6 weeks, students participated in a self-paced individualized academic preparation in math and English on a drop-in basis (minimum 30 hours).
• Hours of engagement with math (direct instruction, facilitated study)
  o 4-week program with approximately 100 hours of math engagement
  o 4- or 6-week program with approximately 80 hours of math engagement
• Number of students in bridge program
  o 12-15 students
  o 30 students
• Length of academic support for bridge students
  o Academic support only during the summer bridge program
  o Academic support continues into the freshman year (e.g., first-year seminar, student support programming)

Which of these variations of a summer bridge program works better? Many of the variations in bridge programs at Penn State have small sample sizes that do not lend themselves to formal statistical comparison against each other. However, informal analyses indicate some patterns in terms of what works better or not in terms of grade point average and retention in Engineering, STEM, and the University.

More math engagement. Even though the recommendation is for a minimum of 30 hours of math instruction during a bridge program, our current bridge programs offer a minimum of 80 hours of engagement with math (direct instruction, facilitated study). One bridge program focuses solely on math preparation with 100 hours of math engagement across a 4-week summer bridge. Students enrolled in that program over the last 2 years performed markedly better in their first college math course than students in bridge programs with 80 hours of math engagement.

Location of bridge program matches the fall semester campus assignment. An important aspect of student success is developing peer and faculty relationships on campus (Chambliss & Takacs, 2014) and acclimating to the physical layout and resources on campus. The bridge program on the University Park campus for regional campus students is less successful in terms of retention in Engineering and STEM than the programs in which students attend a bridge program on the campus they attend in the fall. The first-year bridge program at the flagship campus for regional campus students provides academic enhancement but is limited in that it does not build other essential components on their own campus such as a student learning and support community, relationships with local faculty and staff, and acclimation to their local campus.
Number of students in bridge program. Our bridge programs for incoming first-year students with 15 to 20 students appear to be more successful in terms of first college math course grades and retention in a STEM major than our bridge program with 30 students. It is not clear what is driving that difference and what was lost when the program was scaled up from 12-15 students to 30 students.

Student engagement with each other. Informal analyses indicated that the semi-structured 8-week program was less effective in terms of retention in Engineering than shorter structured programs that put more emphasis on teaching math to a cohort and building social relationships among the participants.

We do have strong data showing the success of the PreF program at Penn State for retaining and graduating underrepresented Engineering students assigned to the University Park campus. For example, examining five cohorts for which 6-year graduation data are available, 68% of students who participated in PreF graduated in Engineering compared to 44% of underrepresented students in Engineering from the same cohorts. An important aspect of the PreF summer bridge program is that support continues beyond the summer through the academic year. During the academic year, the PreF students live together in a STEM scholastic residence hall, enroll together in the same first-year seminars, and are encouraged to participate in the Multicultural Engineering Program (MEP), which offers bi-weekly meetings that provide resources for success in college and the Engineering profession (e.g., study skills, test-taking skills, preparing for job interviews, negotiating a hiring package). Bridge programs designed to achieve a circumscribed outcome that occurs close in time to the end of the bridge program, such as increases in scores in the math placement exam, may be effective as a stand-alone intervention. However, to achieve more complex goals further out in time, such as graduation in a STEM major, bridge programs will be most successful in the context of multiple, ongoing support efforts and resources rather than as a stand-alone intervention. “New students tend to benefit from early interventions and sustained attention during the first year in terms of academic performance” (Kinzie, Gonyea, Shoup, & Kuh, 2008, p. 30).

There is published evidence that comprehensive efforts that include a summer bridge component can be successful in increasing graduation rates of underrepresented STEM majors. The program with the greatest documentation, longest tracking, and greatest success is the Meyerhoff Scholars Program at the University of Maryland—Baltimore County campus, which was started in 1988 (e.g., Carter, Mandell & Maton, 2009; Hrabowski & Maton, 1995; Maton & Hrabowski, 2004). That program focuses on supporting high-achieving underrepresented undergraduate STEM students who are interested in eventually completing a PhD program in a STEM field. The Meyerhoff Scholars Program provides undergraduate students with a 6-week summer bridge program prior to the first year, financial aid, a living-learning residence hall during the academic year, academic-year research experiences, study groups, personal advising, summer research internships, and community service opportunities. Students receive multiple forms of support and academic enhancement over time on the way to the long-
term goals of completing a STEM bachelor’s degree and entering a STEM PhD program.

The goal of the University of Michigan Engineering Academy pilot program for 47 students (St. John et al, 2014) was similar to the Penn State PreF program—to reduce the achievement gap among underrepresented undergraduate STEM students. The Engineering Academy program also included multiple supports including academic, social, and financial components. The four components were a 6-week summer bridge program, a living-learning community during academic year, structured support services during the academic year (academic, peer, and industry advising; professional development activities; career exploration; internship after freshman year), and a stipend of $3000 (part paid out at the end of the bridge program and part paid at the end of the first fall semester). There was limited longitudinal follow-up. They examined participants’ first fall semester GPAs and found the average was higher than the predicted GPA for similar students.

Strayhorn (2011) reported the results of a 5-week bridge program intended to improve college preparation and retention in a sample of 55 underrepresented undergraduate students across all majors at a primarily White institution. Participants were assessed only through the end of the first semester on grades, academic self-efficacy, sense of belonging, and academic and social skills. Compared to the beginning of the bridge program, participants reported an increase in academic self-efficacy and academic skills but there was no change in sense of belonging or social skills at the end of the program. There was a small but statistically significant association between academic self-efficacy and first-semester grades.

It is not known how many weeks a summer bridge program should be to be successful (however success is defined) or how many or how few additional support components during the academic year are necessary to increase retention and graduation rates. The 11 published summer bridge studies reviewed by Sablan (2014) were stand-alone interventions and not part of larger comprehensive support programs. A stand-alone bridge program may be adequate if the goal is modest, circumscribed, and measured close in time to the conclusion of the bridge program, such as increasing scores on a math-placement exam. However, more long-term and challenging goals such as graduation with a STEM degree will require comprehensive, multi-faceted, and ongoing support.

How “skinny” can a bridge program be and still be effective? We don’t know. My educated opinion is that a summer bridge program alone without ongoing support during the academic year will be less likely to result in higher retention of underrepresented STEM students. Summer academic enhancement in the absence of any community building is not likely to be effective in terms of increasing grade point averages or retention. The additional support activities during the academic year might include clustering students on the same floor of one dorm, clustering students in a first-year seminar, clustering students in the same math class, enrolling students in undergraduate research experiences, connecting students with related student
organizations (WEP, MEP, NSBE, SHPE). All these actions integrate students into the University community, increase the likelihood of peer self-help and collaboration and increase a sense of belonging (Tinto, 2010).

**Strategies for Sustaining Bridge Programs for Underrepresented Students**

Long-term improvements in the pipeline of a diverse STEM workforce starts with sustaining effective bridge programs that can produce more Engineering baccalaureates. In addition to student retention, an important outcome of any intervention program is whether it can be sustained beyond the end of the time-limited external or internal funding. Bridge programs can only support Engineering students as long as they exist. They can exist only as long as they are funded. The challenge with bridge programs is that they are costly and those costs repeat and increase each year. “Sustainability implies a long-term ownership commitment, a challenge of the first order for many programs whose base of support is usually in the form of external funding from the state or federal government” (BEST, 2004; p. 26). The most obvious aspect of sustainability is financial support. However, the participation of staff and faculty who have the passion and knowledge about implementing bridge programs is a crucial aspect of sustainability. The sustainability plan for the Toys’n MORE project focused on requiring matching funds from the local campuses and providing data to administrators at the end of the project and was too limited. When the Toys’n MORE funding ended, one of the three campuses was able to support their STEM summer bridge program for only one more summer. Reflecting on the Toys’n MORE project, a sustainability plan needs to start at the beginning of any time-limited funding. For the Engineering Ahead project, we are pursuing three strategies for the long-term sustainability of summer bridge programs at Penn State Abington, Altoona, and Berks:

- **Engage the campus administration early on**
  - Share the positive results of previous bridge projects
  - Request a financial contribution for the summer bridge programs for each year of external funding
  - Meet in person annually to discuss progress and strategic support planning for these projects through the Development Office or the Career Services Office and/or institutionalization of all or portions of the bridges.

- **Generate data** to show the positive effects on retention on underrepresented minority students in Engineering.

- **Support an Engineering bridge leader** at each of the three regional campuses to manage the local bridge efforts and build institutional knowledge. This person has four responsibilities:
  - Recruit for and implement the summer bridge for incoming first-year students
  - Run a first-year seminar during the fall semester of the academic year with the students who participated in the summer bridge
  - Participate in bi-weekly professional development meetings with the Principal Investigator and other regional campus Engineering bridge leaders on strategies to implement and sustain summer bridge programs
Develop internal and external partners to support their local bridge program

The goal is to encourage the regional campuses that are offering Engineering bridge programs to collaborate and to strategize about sustaining funding for Engineering summer bridge programs. Learning communities are not just for students. We strive to create a learning community among the regional campus Engineering bridge leaders and Co-PIs and have bi-weekly conversations to discuss best practices for implementation and strategies for raising summer bridge funds from local or national companies. The goal of the Engineering bridge leader learning community is to create, over time, a culture of supporting Engineering summer bridge programs, figuratively and literally.

Developing a sustainable program of support for Engineering bridge programs is particularly important for 2-year colleges because they touch half of all college students (Bellafante, 2014), resources are limited, there is not a tradition of summer bridge programs, and there is high need to intervene in the first two years of college when attrition out of Engineering and STEM is the highest. It may not be realistic to expect that small regional campuses will be able to devote hard monies for 100% of the funding of Engineering summer bridge programs. The vision for the long-term sustainability of regional Engineering bridge programs for underrepresented students is that it will be more likely if a portion of the funding can be raised through other or multiple sources. The most desirable source of sustainable funding would be an endowment. In the absence of an endowment, funding for summer bridge programs could be put together from one or more other sources such as the local campus, industry (local or national), foundations (local or national), and the student participants. The challenge of asking the student participants to pay for the summer bridge program is that those most in need of the program may be the least financially able to pay for participating. However, a strategy for retaining students in an academic enhancement program is for them to be invested by making a financial contribution. The size of the financial contribution should be modest so that it does not deter the population being recruited.

Data can support the argument for the need for a bridge program as well as the efficacy of a program. The need for a summer bridge program can be supported by examining institutional data benchmarks. For example, what are the graduation rates of underrepresented students in Engineering compared to graduation rates of majority students in Engineering? To demonstrate the efficacy of a summer bridge program it is important to compare the outcome of interest (GPA, math course grades, retention at the end of the first year, retention in a particular major, academic self-efficacy, sense of belonging) against some benchmark. The benchmark might be the change in scores from a pre-test to a post-test. For benchmarks such as GPA, retention in a major, or graduation rates in a particular major, the most rigorous way to evaluate the efficacy of an intervention is to have random assignment of participants to the experimental group or to a control group. This research design is difficult to achieve because sample sizes are often small or there is no appropriate control condition. If there are 20 students in a bridge program and half are assigned to a control group, that leaves a very small sample size exposed to the intervention with small statistical power for detecting group
differences. However, it should be noted that random assignment is possible when studying bridge programs. Wathington et al (2011) used random assignment to treatment or control groups with a large sample of 1,318 students. A second way of generating a comparison group of students is to match important characteristics of participants to students in the same cohort who did not participate. For example, we match each of our bridge participants to non-participants in the same entering cohort on sex, race, major, campus location, and SAT Math scores (within one standard deviation). One strength of comparing students in the same cohort is that they are under the same institutional policies and conditions.

The Center for Engineering Outreach and Inclusion at Penn State

Support for students is more likely to be effective when people in related institutional units are informed about the activities of other related units and work together. Synergy among staff and programs can enhance our ability to retain and graduate underrepresented students in Engineering. The Center for Engineering Outreach and inclusion (CEOI) at Penn State is comprised of five units: the Multicultural Engineering Program, the Women in Engineering Program, Student Research and Engagement, Campus Outreach, and the NSF-funded Engineering Ahead project. We meet weekly to share information and work together so that students can benefit from the resources across the units. In addition to the units within the CEOI working together, we also work closely with the Engineering Advising Center to direct students into programs that will enhance their college experience and success.

Conclusions: Lessons Learned and Recommendations for Successful Summer Bridge Programs

These recommendations are derived from experience with summer bridge programs for Engineering or STEM students, but many apply to summer bridge programs with broader populations.

- Be clear about the outcome you want to achieve with a bridge program. How complex is that goal and when will it be achieved relative to the completion of the bridge program? More complex goals further out in time from the administration of the bridge program will require additional ongoing support efforts to achieve success. It may be difficult for a stand-alone bridge program for incoming first-year students to be successful for complex goals that occur several years after the student attends the bridge program, such as graduation with a STEM baccalaureate.
- Start working on long-term sustainability from Day One.
- Champions are necessary at two levels. For bridge programs to be sustained it is important to have support from upper administration as well as a passionate person “in the trenches” who can do the challenging work of implementation.
- A charismatic and deeply devoted student-centric bridge director can be a key source of social support and a “sense of belonging” for students during the academic year (for example, our MEP Director, greeted his first-year bridge
students as they came out of a big chemistry exam to give each of them a “high 5”).

- More intensive recruitment is often needed to recruit underrepresented students into summer bridge programs (e.g., personal phone calls and emails from faculty and current students who were former bridge students).
- What is the least amount that a summer bridge program can cost for it to still be successful? In general, we do not know the answer to that question. A large part of the answer hinges on the goals of the summer bridge program and how “success” is defined.
- Leverage local resources
  - Does your campus require first-year seminars in the fall? If so, cluster the bridge students in one so that they remain together during the fall semester and there is no additional expense for the bridge program or the students.
  - Do you have an office that facilitates and coordinates undergraduate research? If so, facilitate introductions so the bridge students are encouraged to participate in that undergraduate research.
  - Do you have student organizations that are particularly relevant to your bridge students and can provide ongoing social and professional support? For example, on the University Park campus the PreF students are introduced to the local chapters of the National Society of Black Engineers (NSBE) and the Society of Hispanic Professional Engineering (SHPE).
- Build relationships across campus
  - Does your campus have a Learning Center that you can partner with for tutors? For example, one of our math instructors kept his first-year summer bridge students together into the spring semester with a 1-credit study hall. He negotiated with his Chancellor for $1000 to cover his salary for the 1-credit course and coordinated with the Learning Center to provide 2 physics tutors and 1 chemistry tutor during that hour for his bridge students.
- Ongoing academic support and support for the bridge learning community during the academic year is crucial to long-term student success and retention.
- How to deal with the heterogeneity in math skills during a summer bridge program when some first-year students are placed into pre-calculus and some are placed into calculus? Divide the students into two groups and either have two different instructors or one instructor with different assignments for each group.
- Non-residential bridge programs need to put additional effort into building a learning community among their students. A structured program will be more effective toward this end compared to a less structured program where students engage in more independent learning.
- How many weeks should be a summer bridge program be? We do not know (Sablan, 2014). What is important is that the program is long enough or intense enough for students to form a learning community that will carry over into the fall semester. The 2-week bridge program during the Toys’ n MORE project was particularly intense and the students formed solid relationships with each other. That program was more successful in terms of retention in Engineering than the
8-week semi-structured program. My educated opinion is to recommend that bridge programs be 4 or 6 weeks and structured to promote proficiency in math and the formation of social bonds among the bridge students.

- Funding for a summer bridge program may need to come from multiple sources: Endowment funding, Federal grants, the local college, industry (local or national), foundations (local or national), student participants.

- Should incoming first-year bridge students re-take the university math-placement exam after the bridge program to try to place into a higher math course for the fall semester? It depends. For our bridge students entering a competitive undergraduate Engineering program, we recommend that they do not re-take the math placement exam after the bridge program or do not change their original math placement if they do re-take the math placement exam. In our 2016 bridge cohort, two thirds of them re-took the university math-placement exam and most placed into a higher math course. Half of those who moved into a higher math course than their original math placement score indicated had a D/F/W in math at the end of the first semester. Students who had a large increase in their math placement exam score from the first to second time that they took it tended to do worse in their fall semester math courses. Among our Engineering Ahead bridge students, there was a strong correlation between their first math-placement exam score and their SAT Math score, suggesting that the first math-placement exam score is indicative of their math aptitude.
References


